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1.1 EN-ROUTE DRIVER INFORMATION

1.1.1 Introduction

The En-Route Driver Information user service provides travel-related information to drivers after their trips have begun. This user service includes the Driver Advisory sub-service which provides real-time information on traffic, transit and roadway conditions. The In-vehicle Signing sub-service provides in-vehicle displays of roadway signing and warnings of road hazards, traffic controls or special roadway conditions. Users of the service include drivers of private, commercial and transit vehicles.

Related services include information provided to transit riders during the trip through En-Route Transit Information (User Service No. 3.2). Information received before the start of a trip is covered under Pre-Trip Information (User Service No. 2.1). Travel Services Information (User Service No. 1.3) and Route Guidance (User Service No. 1.2) could be provided in conjunction with the Driver Advisory component of this service.

1.1.2 Needs

The nation's highways are faced with very high levels of *congestion*. Congestion has become a national issue, with cover stories in national magazines highlighting "gridlock" as a major public policy issue for the 1990s. Projected traffic growth, coupled with the difficulty of providing adequate additional lanes for new capacity, suggests that congestion will continue to be a major issue in many metropolitan areas.

Traffic network efficiency may be increased by permitting drivers with better information about the traffic network to choose routes that are away from congested areas, thus helping to balance the demand on the network through better use of its capacity. Advisory information will be updated dynamically throughout the trip as traffic, weather, or other conditions change. Drivers may be advised to switch to another mode of transportation, and provided with information on transit schedules and parking availability at the nearest transit stop. Currently, some of this information is available through commercial radio broadcasts, changeable message signing, highway advisory radio broadcasts and personal radio (e.g., citizens' band radio) communications. Intelligent Transportation Systems (ITS) technologies hold the promise of providing more timely and reliable information to drivers.

Safety on our nation's highways is an important public health problem. The public's concern has been manifested politically in many geographic areas by seat belt, helmet, and tough drunk driving laws, and in the marketplace by the increased market penetration of such equipment as air bags and anti-lock brakes. Design standards for highways also reflect this emphasis; however, safety is a continuing problem on the nation's highways. Rural accidents are of special concern, since 60.9% of fatal accidents occur in rural areas where collision

speeds are likely to be higher. Train-related incidents in rural areas are also a concern. Traffic accidents cost the country an estimated $70 billion in lost wages and other direct costs annually. The economic loss from traffic accidents is 2% of the U.S. gross national product.

Drivers require information related to the roadway and driving environments in order to operate their vehicles in a safe manner. Providing information that more closely reflects the actual conditions of the roadway and driving conditions can enable drivers to operate their vehicles more safely by either avoiding dangerous conditions or driving in a more alert manner.

1.1.3 Service Description

En-Route Driver Information is composed of two sub-services: driver advisory and in-vehicle signing.

Driver advisory information benefits the driver in terms of convenience, cost, time, perceived safety, and reliability when incidents, roadway congestion, construction, or hazardous environmental situations occur on the roadways. Smoother traffic flow resulting from reduced congestion, improved route selection, and trips shifted to public transportation systems can significantly reduce air pollution.

In the short-term (5-10 years), there would be a fairly simple deployment of *in-vehicle signing*, where only a limited number of roadway signs would be equipped with the in-vehicle signing capability. These would include control signs (stop, yield, etc.) and warning signs (curve, intersection, etc.). Initially in-vehicle signing will be limited to small groups of users with special requirements. Examples of potential users include:

- Individuals who might have difficulty with night vision, in areas where the number of potential users makes the infrastructure investment worthwhile, e.g., older drivers living in areas with a large concentration of senior citizens.

- Rental vehicles that would receive voice or visual prompts at airports giving them directions on how to find the rental agency parking lot or how to exit the airport, e.g., "To head downtown, turn left at this intersection."

- Rental vehicles in a resort/recreation area that would receive safety warnings for drivers unfamiliar with treacherous terrain or potentially poor visibility.

- Transit or commercial vehicle operators would receive information such as preferred routings or on-time status.

1.1.4 Operational Concepts

In the long term (10 years and beyond), in-vehicle signing could become more prevalent and would probably show a regional preference (i.e., some areas would deploy it and others wouldn't). Local deployment might also be funded by groups of users, such as transit operators, rental car companies, or local delivery fleets.

It is envisioned that, as more vehicles become equipped with other ITS equipment (i.e., video displays, head up displays, voice input/output), stand-alone vehicle signing equipment will become less prevalent and in-vehicle signing will be integrated with other ITS. It is anticipated that existing highway signs will, largely, remain in place. On automated highways, elimination of visual signs may be possible since all vehicles using the system will have automatic control. Many of the same types of data provided to drivers today using physical signs could be provided to automated vehicles via the same technology used to communicate in-vehicle signs. Potential long term in-vehicle signing applications include:

- Providing warnings based on the characteristics of the vehicle (e.g., warning trucks about steep ramps) or the current environmental conditions (e.g., wet pavement, ice, snow, etc.)
- Alerting motorists that they are exceeding the safe speed limit
- Warning motorists of unsafe curves, and providing safe speeds based on vehicle type and road conditions
- Warning motorists of unsafe weather conditions (e.g., ice, snow, fog, dust clouds) based upon roadside environmental sensors.

1.1.5 Technologies

1.1.5.1 Driver Advisory

Driver advisory functions require some equipment for each vehicle. In its simplest form, driver advisories could be provided as auditory messages using FM sideband or other relatively inexpensive communications technologies within the vehicle. Driver advisories might also be provided through a variety of electronic devices that might also be capable of receiving information at home, office, and at convenient public locations through a variety of technological means and media. These devices will require advanced communications and microprocessor techniques to accommodate a variety of driver and transportation network requirements.

Communications media and technologies to provide accurate and reliable transportation information to the in-vehicle device are being researched under Federal Highway

Administration (FHWA) programs. FM subcarrier communications techniques that use existing infrastructure, spread spectrum two-way radio, microwave and infrared beacon, and cellular radio, and transponder-based vehicle-to-roadside systems are some of the candidate technologies being evaluated. Information dissemination techniques such as roadside displays, in-vehicle head up displays, video monitors, and other audio or visual presentation methods are also being evaluated.

1.1.5.2 In-Vehicle Signing

In-vehicle signing information would be presented to drivers in various media to accommodate the diverse needs of the driving public. Sign information could be presented to the driver as voice output and/or a head up or other visual display. Such use of audio and visual presentation to overcome hearing and visual impairments will make the surface transportation system more accessible, and increase safety, especially in adverse driving conditions.

There would probably be limited integration of in-vehicle signing with other ITS user services. That is, if the vehicle already has a head-up display or a voice response system, in-vehicle signing could take advantage of it. Otherwise, the in-vehicle signing equipment would be a stand-alone unit. In transit vehicles, where stand-alone equipment is generally not desirable, the signing equipment would conform to applicable SAE J-1708 VAN standards.

Communications media and technologies to provide accurate and reliable signing information to the in-vehicle device are being researched under FHWA programs. Directional microwave and infrared beacon communications techniques, spread spectrum radio, transponder-based vehicle-to-roadside systems, and variations of Highway Advisory Radio (HAR) radio are some of the candidate technologies being evaluated. Information presentation methods are also being evaluated and coordinated with ongoing Human Factors research and development activities to prevent information overload to the driver.

1.1.6 Potential Costs and Benefits

1.1.6.1 Driver Advisory

The benefits of driver advisory information will likely be experienced by all segments of the population. For example, measurable reduction in traffic congestion presents obvious advantages for the traveler, but the indirect consequences are also significant. These include reduction of "secondary" or congestion-related accidents, improved transit service, less fuel wasted from sitting in traffic jams, and fewer emissions from idling engines. Productivity gains result not only from workers who waste less time commuting, but also from lower commercial trucking costs and greater returns on capital investment in public transportation.

Increased collection and creative use of information will assist drivers in making informed decisions to use transit and other ride-sharing arrangements. Less vehicle-miles of travel will result, with associated environmental and energy conservation benefits. Personal mobility will be enhanced by making services better understood and more accessible, especially to the transportation-disadvantaged, including the elderly and disabled, and residents or visitors in geographically remote communities.

1.1.6.2 In-Vehicle Signing

The benefits of in-vehicle signing information will likely be experienced by all segments of the population. Benefits include reduction of accidents related to "inattentive" conditions caused by driver boredom, poor weather conditions, disruptive situations, and "secondary" or congestion-related accidents. Personal mobility will be enhanced by making traffic and roadway conditions better understood and more accessible, especially to the transportation-disadvantaged, including the elderly and disabled.

1.1.6.3 Public Benefit of Entire User Service

The En-Route Driver Information service has potential for high public benefit since the reduction in congestion promises to remove much of the uncertainty, aggravation, frustration, fatigue, and general stress associated with travel that many of us experience today. The potential for increased safety through reduction of traffic accidents is also considered a high public benefit.

1.1.7 Assessment of Roles

Responsibility for development of ITS services generally resides with the private sector; however, there are situations when U.S. Department of Transportation (U.S. DOT) involvement is appropriate. This would include cases with high public benefit but low commercial potential. Another example is where the government, rather than the private sector, is a substantial or primary user of the service. If both the expected public benefit and the commercial potential are high, the U.S. DOT will encourage a joint public/private development effort. This approach, which underlies the U.S. DOT's strategy for investment in ITS technologies and systems, is used below to assess the appropriate role for the U.S. DOT in the En-Route Driver Information system development.

1.1.7.1 Potential for Private Investment in Development

The potential for private investment in driver advisory products appears to be high. These devices may be offered as stand-alone units during the early deployment of ITS, but eventually the in-vehicle units will provide the capabilities to allow the system to incorporate a wide range of user desirable features and options.

There may be less potential for private investment in in-vehicle signing; as it may have a lower degree of demand from potential users compared with other ITS services. Initially, the private market is probably limited to groups with special requirements, although recreational tourists may also represent a potential market. Relatively simple in-vehicle signing, for example a display of the current speed limit, may also attract a consumer market. As the level of sophistication of the service increases, including dynamic warnings of unsafe driving (e.g., approaching stop sign or red light at excess speed), additional demand for the service will probably evolve. Demand will also evolve as geographic coverage of the service is expanded.

1.1.7.2 Public and Private Sector Roles in Deployment

The deployment of the En-Route Driver Information service will be a public/private partnership. While the information infrastructure that carries transportation information will likely be privately developed, the public sector will probably have a role in ensuring that mode choice and other information to encourage ride-sharing and public transportation is included. The overall public sector role in deploying driver advisory products will be medium, although the implementation of infrastructure elements will be somewhat higher. The operation and maintenance of the infrastructure (roadside) components is expected to be a public sector role, but some innovative technologies may be implemented by the private sector. The willingness of private, commercial, and transit drivers to pay for en-route driver advisories will determine the market for products and services provided by the private sector.

The public sector will implement the infrastructure elements for in-vehicle signing, while the in-vehicle components will be consumer items provided by the private sector. The operation of the infrastructure (roadside) components is expected to be a public sector role, with costs borne by the public sector.

1.1.7.3 U.S. DOT Role in Developing Service

The U.S. DOT will have both a direct and supporting role in the development of the En-Route Driver Information service.

1.1.7.3.1 *Research and Development*: The U.S. DOT role in research and development is high for addressing communications, database, human factors and safety issues that might impact development and deployment of the service. The private sector will be responsible largely for developing prototype products for operational testing of this service.

1.1.7.3.2 *Operational Testing*: The U.S. DOT role will be high in fostering public/private partnerships to operationally test this service. This service will likely be tested as part of an integrated system encompassing other services, and the U.S. DOT role will be to ensure careful evaluations of the safety and operational impacts of the service are performed. In

addition, the U.S. DOT will ensure that sites are chosen to provide sufficient operational testing to accommodate a variety of final deployments.

1.1.7.3.3 *Institutional and Legal:* The U.S. DOT role in addressing institutional or legal barriers to deployment is medium. It is expected that many of the perceived problems will be resolved through the initiative of the private sector.

1.1.7.3.4 *Deployment*: The U.S. DOT will promote the development of the necessary standards and guidelines, some of which are needed to ensure interoperability, while others may be needed to ensure safety. The U.S. DOT will foster the public portion of deployment, which, for this service, might be roadside infrastructure needed to collect and disseminate real-time information about the transportation system. The U.S. DOT will also foster and encourage the inclusion of travel-related information in privately-provided information systems.

1.1.8 Milestones and Activities

Figure 1.1-1 presents a Gantt chart depicting the key activities, milestones, and, if applicable, decision points associated with developing this user service to a state where it is available for deployment. The accompanying supporting text identifies probable issues and describes the activities, with associated projects, identified on the Gantt chart. An issue is defined as a major potential challenge which has to be met in order to achieve deployability.

1.1.8.1Driver Advisory Sub-Service

Issues:

The key issues are data-oriented on what technologies can be used to achieve the following: collect the data, process the data into information, maintain accurate databases and keep them current, and disseminate the information to drivers in an effective and safe manner. Non-technical issues such as product liability may also have to be addressed.

Activities:

1. Driver Advisory R&D, including studies on System Concept, Communications, Map Databases, and Human Factors.

   Questions to be addressed:

   - What methods can be used to provide driver advisories to drivers?
   - How do drivers react to and use this information?

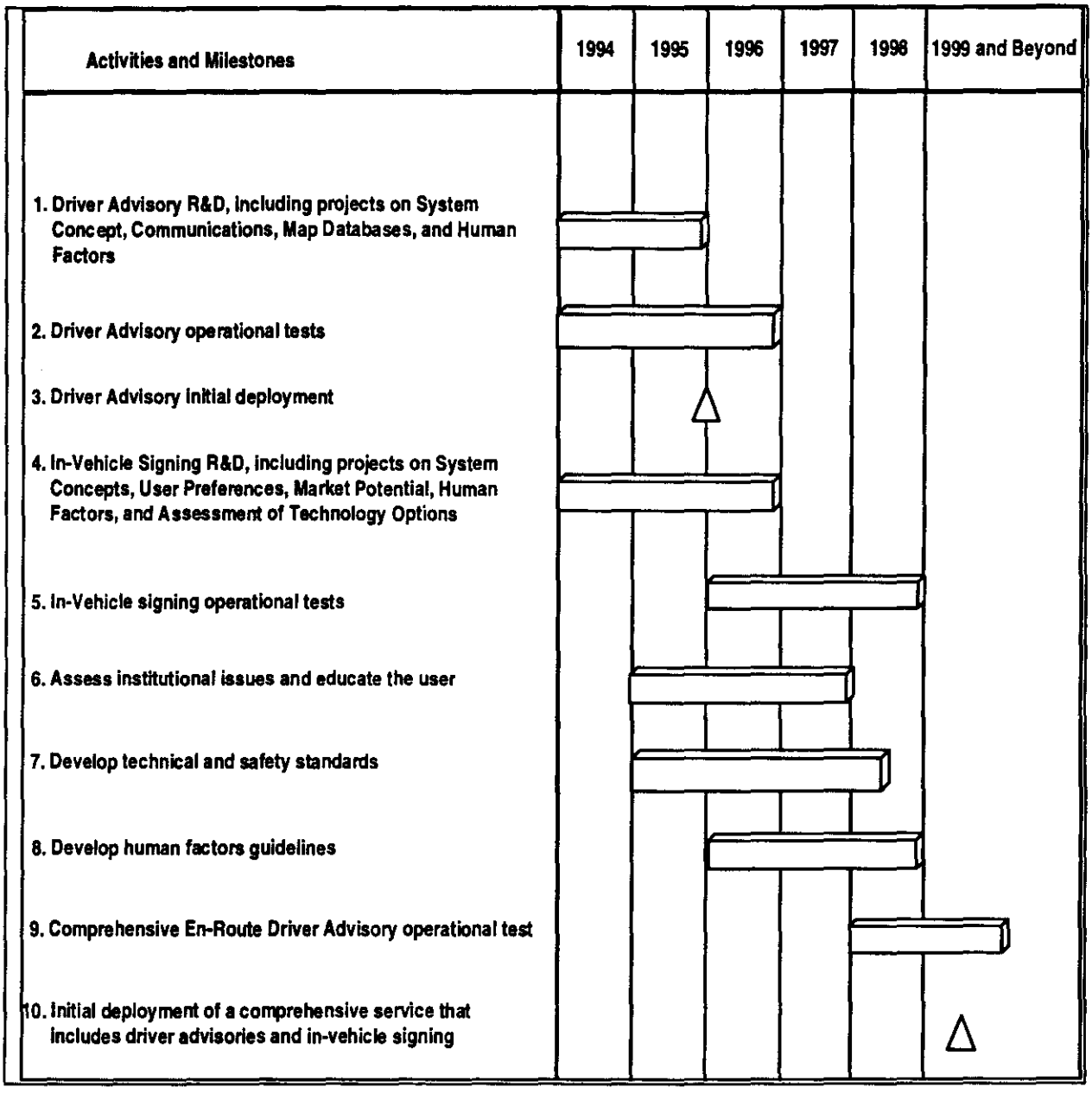

Figure 1.1-1 En-Route Driver Information Activities

- How much will drivers be willing to pay for the in-vehicle technologies that provide this service?
- What are the safety implications of these technologies?
- What are the costs/benefits associated with the technologies for providing driver advisories?
- How can information reliability be ensured?
- What are the technical constraints to using these technologies?
- What are the non-technical constraints to using these technologies?

The following R&D projects have been initiated by FHWA:

- ITS Communications Alternatives Test & Evaluation will identify and analyze communications technologies for ITS functions, and recommend preferred communications alternatives for specific ITS functions.
- ITS Radio Frequency Spectrum Planning will identify emerging RF needs of ITS, ensure spectrum is available when needed, and ensure electromagnetic compatibility with other communications systems.
- FM Subsidiary Carrier Authorizations (FM/SCA) Prototype for Traffic Information Broadcast will design, develop, and pilot test a Subcarrier Traffic Information Channel (STIC) prototype system for broadcast of traffic information to mobile receivers.
- Analysis of Traveler's Preference for Routing will analyze the criteria and decision processes used by drivers for selecting routes, choosing departure time, and rerouting when encountering congestion.
- FHWA is sponsoring a study to assess user requirements and feasibility of rural applications for advanced traveler information systems. A follow-up study will pursue development and prototype testing of the most promising concepts.

2. Driver Advisory Operational Tests (Many of these tests are also evaluating other services used in conjunction with driver advisories.)

- Pathfinder--A control center transmitted congestion information to equipped vehicles. The information was presented to the driver in two ways: on an electronic map on a display screen, or by digital voice.

- TravelAid--Information on hazardous weather and driving conditions through the Snoqualmie Pass in Washington State will be provided to drivers.

- TravTek--A Traffic Management Center obtained traffic congestion information from various sources and used digital data radio broadcasts to broadcast this information to 100 equipped vehicles. Routes were developed based on driver-selected criteria and presented to the driver by synthesized voice and map display.

- ADVANCE--Up to 5000 vehicles will be equipped with in-vehicle navigation and route guidance systems to evaluate their use by local commuters in a typical urban setting. This project will also evaluate the use of equipped vehicles as "traffic probes."

- Genesis--Portable digital Personal Communications Devices (PCDs) will be designed to receive various real-time traffic and transit information. Project is being conducted by Minnesota as part of Guidestar.

- The Washington, D.C. metro area surveillance test is evaluating the use of digital cellular packet data transmission for providing in-vehicle traveler information.

- The TravInfo project in the San Francisco Bay area is evaluating a broad array of devices for providing information to travelers both before and during their trips.

- The Idaho Storm Warning System is evaluating three environment sensors to detect hazardous visibility conditions and automatically activate messages on overhead variable message signs.

- The Herald project is evaluating the use of a subcarrier on AM as a low-cost medium for transmitting traffic messages over a wide geographic area. The test is also assessing the suitability of the International Traveler Information Interchange Standard (ITIS).

- The TransCal project is evaluating inter-regional traveler information and assessing the ability to integrate information from multiple regions, and to integrate traveler services and transit information with real-time regional congestion and incident data.

- The Atlanta en-route traveler advisory project is evaluating the use of FM subcarrier wide area communications systems and applications of 220 MHz frequency pairs.

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The Northstar project is building on an existing privately-developed traveler information service called Traveler Assurance Services (TAS). The project is evaluating the use of FM subcarrier combined with speech synthesis and cellular telephones to provided personalized incident reports and route guidance.

- Based upon results of R&D tasks, additional operational tests will be conducted on in-vehicle use of PCDs.

3. Driver Advisory Initial Deployment

- Initial deployment will be the broadcast of advisory messages to all vehicles over commercially available radio; more sophisticated deployment capabilities, including messages tailored to a specific route, will evolve.

1.1.8.2 In-Vehicle Signing Sub-Service

Issues:

The Driver Advisory Sub-Service issues are relevant here. In addition, a determination is needed as to which types of signs are amenable to for in-vehicle signing, and how to output them to drivers in a safe and effective manner.

Activities:

4. In-Vehicle Signing R&D

Questions to be addressed:

- What methods can be used to provide In-Vehicle Signing information to drivers?
- How do drivers react to and use this information?
- What are the safety implications of these technologies?
- What are the costs/benefits associated with the technologies for providing in-vehicle signing?
- What are the technical constraints to using these technologies?
- What are the non-technical constraints to using these technologies?

The following R&D projects will be conducted by FHWA:

- In-Vehicle Signing (IVS) R&D (1994 and beyond) will investigate technologies and issues associated with IVS systems, including a benefits analysis, definition of functional requirements, and system/concept analysis.

- If the benefits warrant continuation, a consortium will be formed to further develop, test, and make available for deployment an operational IVS system.

- Human Factors R&D will determine how in-vehicle signing can be safely deployed.

5. In-Vehicle Signing Operational Tests

   - Tests will be conducted on a limited set of in-vehicle signs in order to determine how they may best displayed and merged with other types of information.

6. In-Vehicle Signing Initial Deployment

   - Selected target populations of drivers are candidate users for early deployment of in-vehicle signing by the states. These populations might include elderly drivers or drivers of rental cars. Initially, only a limited number of signs (e.g., stop, yield, warnings of poor visibility, and other signs directly impacting safe operation of the vehicle) will be used.

   - In-vehicle signing capability will evolve over time to provide more signs and to provide signs tailored to the driver's needs (e.g., speed limits appropriate to vehicle class, appropriate exit signs for tourists).

1.1.8.3 Comprehensive En-Route Driver Information Service

Issues:

The In-Vehicle Signing Sub-Service must be integrated with the previously developed Driver Advisory Sub-Service to provide a comprehensive service.

Activities:

7. Assess institutional issues and educate the users

   Questions to be addressed:

   - What are the perceived issues related to deploying En-Route Driver Information?

   - What actions are needed to address these perceived issues?

- How can users be educated to the "reality" of these institutional issues?

- When will radios be available for providing driver advisories and In-Vehicle Signing information?

8. Develop Technical and Safety Standards

   - Information interchange, FM Subcarrier, map database and Human Interface standards will be developed. Safety standards will be developed by NHTSA to ensure that map or other information displays and in-vehicle signs do not distract drivers or adversely affect safety.

   Questions to be addressed:

   - What terminology conventions need to be developed?

   - What communication standards are needed to facilitate deployment of En-Route Driver Information?

   Projects:

   - Map Database R&D will develop a referencing system to establish unique traffic link identity and determine database accuracy, reliability, and compatibility requirements.

   - FHWA is funding the Link Identification Format and Map Database Requirements project. Recommendations will be developed for standardizing the information format, content, and accuracy of a nation-wide map database. A format for uniquely denoting links for any part of the country/North America will be recommended.

   - Based on the system architecture work, in fiscal year 1995 FHWA will begin development of wireless communications protocols and driver interface standards to support traveler information user services.

9. Develop Human Factors Guidelines.

   Questions to be addressed:

   - How can driver advisories and In-Vehicle Signing information be presented to users in an understandable and safe fashion?

   - How much information is "too much" for a user to reasonably comprehend and react to?

Projects:

- FHWA is sponsoring a contract with Battelle on Human Factors in Advanced Traveler Information Systems. This project will address the impacts of driver interfaces, information type, behavioral factors, and user demographics on the development of specific information subsystems, including In-Vehicle Signing. Human factors guidelines will be developed so that safety can be maintained.

- NHTSA will develop Federal regulations or guidelines on the safety aspects of the driver advisory and in-vehicle signing systems.

- FHWA will develop Federal guidelines on the terminology used in providing information to drivers.

- FHWA will develop human factors guidelines for enhanced display of the highway environment.

10. Comprehensive En-Route Driver Advisory Operational Test.

    - FHWA will conduct a comprehensive operational test that integrates the two sub-services. The test will use Federal standards and guidelines developed under activities 8 and 9.

11. Initial deployment of a comprehensive service that includes driver advisories and in-vehicle signing.

    - States will deploy infrastructure to support the service.

    - Integrated in-vehicle displays will be developed to provide travel advisories, routing instructions, and signing. Available information will become more sophisticated and will be tailored to the driver's needs, the type of vehicle, and the road conditions.

1.2 ROUTE GUIDANCE

1.2.1 Introduction

The Route Guidance user service provides travelers with instructions on turns and other maneuvers to reach their destinations. These directions could be based upon static information (e.g., the road network, transit schedules). As the service matures, static information about the transportation system will be supplemented by real-time information. Thus a fully deployed Route Guidance service will rely heavily on real-time information provided by the following user services: Traveler Services Information (User Service 1.3), Traffic Control (User Service 1.4), Incident Management (User Service 1.5), Emissions Testing and Mitigation (User Service 1.6), Demand Management and Operations (User Service 2.3), Public Transportation Management (User Service 3.1), and En-route Transit Information (User Service 3.2).

This service is closely related to En-Route Driver Information (User Service No. 1.1). In many implementations, the two services could rely on the same information. However, Route Guidance also processes that information into directions for the traveler. Thus a map display (possibly supplemented by indications of roadway congestion) is considered En-Route Driver Information; Route Guidance would use this information to derive a suggested route and instructions.

Users of Route Guidance include drivers of private automobiles, High Occupancy Vehicles (HOV) and van pools, commercial operators, and public transit drivers, especially for non-route specific services such as paratransit and demand responsive transit. Thus Route Guidance is also closely related to Ride Matching and Reservation (User Service No. 2.2), Personalized Public Transit (User Service No. 3.3), and Commercial Fleet Management (User Service 5.6), especially for time-sensitive commercial deliveries. In addition to in-vehicle devices, Route Guidance would be available through hand-held or other personal portable units, to non-vehicular travelers such as pedestrians or bicyclists.

1.2.2 Needs

When travelers are in familiar surroundings and the conditions of the transportation systems remain somewhat constant, generally the maneuvers required to travel to desired locations are well-known. However, as conditions change, better routes usually exist. Being able to determine what these better routes are is a challenge to the traveler. It is also very discomforting not knowing how to maneuver through unfamiliar areas. Traveler safety can also be increased by alerting a driver, pedestrian or bicyclist to unknown route impediments, such as dangerous alignments or unusual geometrics.

Real-time route guidance information can also assist commercial vehicle operators in locating delivery points and in facilitating "just-in-time" pick-up and delivery services. Commercial

productivity can be improved with better routing information.

This service will also facilitate carpooling, ride matching and flexibly routed paratransit services by providing routing instructions to passenger pick-up points based on real-time traffic information.

Providing travelers with improved routing instructions and better routes can improve the quality of travel for the entire transportation network. Overall delay can be decreased by allowing informed travelers to avoid unnecessary delays. Travel delay, wasted fuel, and subsequent environmental pollutants can be reduced by reducing wasted travel time due to navigational error and lost travelers. Traveler stress is decreased by providing additional confidence and comfort in traveling to desired destinations.

1.2.3 Service Description

When fully deployed, Route Guidance systems will provide travelers with directions to selected destinations. These directions will be based on information about current conditions of the transportation systems. This will include current traffic conditions and information on events that are taking place that influence travel routes, such as street closures or construction. Route guidance systems will also have access to status and schedules of transit, rail and other transportation systems to facilitate intermodal connections. Portable devices for use by pedestrians or bicyclists will provide directions that avoid unsafe or inaccessible routes. Directions will generally consist of simple instructions, such as arrow displays or simple voice messages instructing which way to turn onto particular streets, roads, walkways, or transit facilities.

1.2.4 Operational Concepts

Route Guidance systems have essentially two modes of operation: static and real-time. Static systems rely upon unchanging transportation network information to provide travelers with routing instructions to specific destinations. This static information includes mapping information about the roadways and scheduling information for transit, rail or other systems. Real-time systems enhance the information of static systems by providing current travel condition information, such as traffic conditions or dynamic transit schedule information. Further developments in areas such as dynamic traffic assignment, will allow routing instructions to be based on predictions of the traffic conditions that will occur as the trip progresses.

Route Guidance systems operate in two different configurations, depending on the location of the route selection process. Route determination can either be done onboard a vehicle (or other mobile device) or by processors installed in the transportation system infrastructure. The location of this process determines whether the system is mobile-based or infrastructure-based. Mobile-based static systems are autonomous guidance systems that can operate

independent of any infrastructure. Mobile-based real-time systems can operate as autonomous systems, but when available, receive information about the transportation network from the infrastructure and use this real-time information to determine routing. Infrastructure-based static systems use communications between route guidance devices and the infrastructure to receive information on the traveler's desired destination, calculate a route and then provide directions back to the traveler. If current, real-time information is included in the route determination, these systems become infrastructure-based real-time systems.

There are a number of ways that the route guidance device can exchange information with the traveler. Visual displays, keypads, and other touch-sensitive devices can be used by the traveler to enter information and view routing instructions. Audible instructions also may be provided to travelers through computer-generated voice. The traveler may also be able to enter information into the device through a voice-recognition system.

There are a number of different procedures that can be used to determine the traveler's routing. Mobile-based systems will use programs that use the best information available to provide routing instructions to the traveler based upon certain parameters provided by the traveler. These parameters might include avoiding expressway-type highways or areas inaccessible or unsafe for bicyclists. These parameters enable a traveler to customize the routing selection process. Likewise, infrastructure-based systems can permit a traveler to customize a routing, but they can also use the destination of the traveler to provide a routing that is "customized" for the entire transportation network. With this destination information, an infrastructure-based system can determine the extra demand on a transportation system and provide routing information to travelers that is based upon this predicted demand.

1.2.5 Technologies

Route Guidance systems require a navigable digital map database that provides accurate, current, and complete information on the roadway network and its attributes. Navigable attributes include the identification of one-way streets, the location of traffic signals, stop signs or turn prohibitions, and other characteristics which affect the provision of accurate route guidance information.

Route Guidance systems also require a position determination function to permit a route guidance device to locate itself on a map. A number of technologies exist to perform this function. The most sophisticated of these are triangulation techniques, or using trigonometric functions and known reference sites to calculate a location. The known reference locations may be terrestrial, such as those used in the LORAN-C system (land-based radio navigation system operated by the U.S. Coast Guard), or satellite-based, such as used for the Global Positioning System (GPS) or the GLONASS (former Soviet, now Russian, version of GPS) System. To provide the accuracy required by Route Guidance applications, these systems are usually supplemented by dead reckoning and map-matching, described below, to more precisely place the vehicle on the road network.

A simpler locating system consists of reference sites that send their location to devices that are very near. This system may be thought of as a system of "sign-posts" that can transmit location information to route guidance devices as they pass nearby. Either of these systems may be used by any route guidance device, whether mounted in a vehicle or hand-held. Another technique that may be used by vehicle-based devices is known as dead-reckoning. Dead-reckoning uses very accurate sensors to measure how far and in what direction a device or vehicle traveled and keeps track of these measured differences from a starting location to determine a device's location. Dead-reckoning devices in vehicles may also use map-matching techniques whereby the determined location is checked against a map of roadways. This technique assumes that the vehicle will generally remain on roadways and will correct the determined location to position the vehicle on a known roadway.

The means for getting information from and providing routing instructions to travelers may involve many technologies. Visual displays for showing travelers which way to turn, how far to their destinations and other information may be computer screens that can be carried by the traveler, such as personal portable devices. These may also be "touch-screen" displays, enabling travelers to enter information about desired destinations. Displays similar to these can also be used in vehicles to provide information to travelers. Driving instructions may also be given through head-up displays, where the instructions are projected onto the windshield. Therefore, the driver does not need to look away from the roadway to get the routing information. Voice instructions are another means of providing information that does not require the traveler to divert his/her gaze. Similarly, voice recognition technology can permit the traveler to enter information into the route guidance system without requiring any diversion of sight or additional movements by the traveler.

1.2.6 Potential Costs and Benefits

Perhaps the greatest direct benefit to the route guidance system user is the reduction of navigational waste for both personal and business travel. In other words, travelers will not waste as much time selecting a route and subsequently following the route. In systems with real-time traffic information, drivers will be provided with the least-congested route, further reducing travel time. In addition to reduced overall travel time, personal stress can be reduced by not having to search for landmarks or signs for routing directions. From a transportation system and general society point of view, this reduced time will result in reduced environmental impacts from vehicles.

1.2.7 Assessment of Roles

The responsibility for development of Intelligent Transportation Systems (ITS) services generally resides with the private sector; however, there are situations when the U.S. Department of Transportation (U.S. DOT) involvement is appropriate. This would include cases where private industry might not pursue development on its own, such as the initial development and evaluation of systems with high public benefit but low commercial potential.

Another example is where the government, rather than the private sector, is a substantial or primary user of the service. If both the expected public benefit and the commercial potential are high, the U.S. DOT will encourage a joint public/private development effort. This approach, which underlies the U.S. DOT's strategy for investment in ITS technologies and systems, is used below to assess the appropriate role for the U.S. DOT in Route Guidance development.

1.2.7.1 Potential for Private Sector Investment in Development

The potential for private investment in the route guidance service, including development of routing algorithms, route data bases, and hardware, appears to be high. While there can be significant benefits derived from autonomous route guidance systems, unless the route guidance system can provide instructions based on current information, the market will probably remain low.

1.2.7.2 Public and Private Sector Roles in Deployment

Deployment of dynamic route guidance systems will be a public/private partnership, because of the interdependency between the end-user route guidance device and the supplier of current transportation-related information. It is likely that the public sector, at least initially, will be responsible for deploying the infrastructure that is required to provide real-time communications between the supplier and processor of current transportation-related information and end-user route guidance systems. However, the private sector may also provide the real-time information since it will increase user benefits and thus increase the market potential for route guidance systems. The public sector will likely be the accumulator and processor of real-time information, primarily through the Traffic Control service, although the information networks necessary to collect and disseminate information for dynamic route guidance systems might be provided by either the public or private sectors.

1.2.7.3 U.S. DOT Role in Developing Service

The U.S. DOT will have both a direct and supporting role in the development of the Route Guidance service.

1.2.7.3.1 *Research and Development*: The U.S. DOT role in research and development is high for addressing technical issues such as communications and map database requirements, that might impact development and deployment of the service. The U.S. DOT role will also be to support research in human factors related to the display and provision of route guidance information to travelers. The private sector will be responsible largely for developing prototype products for operational testing of this service.

1.2.7.3.2 *Operational Tests:* The U.S. DOT role will be high in fostering public/private partnerships to test this service operationally. This service will likely be tested as part of an

integrated system encompassing other services, and the U.S. DOT will ensure careful evaluations of potential safety and operational impacts of the service. Other issues to be examined through operational testing include how current information impacts the use of route guidance systems, and how users perceive the value of route guidance systems. In addition, the U.S. DOT will ensure that sites are chosen to provide sufficient operational testing to accommodate a variety of final deployments.

1.2.7.3.3 *Institutional and Legal*: The U.S. DOT role in addressing institutional or legal barriers to deployment is medium. It is expected that many of the perceived problems will be resolved through the initiative of the private sector.

1.2.7.3.4 *Deployment:* The U.S. DOT will promote the development of necessary standards and guidelines, some of which are needed to ensure interoperability, while others may be needed to ensure safety. The U.S. DOT will also foster the public portion of deployment, which, for this service, is the roadside infrastructure required for the collection and dissemination of information about the transportation system.

1.2.8 Milestones and Activities

Figure 1.2-1 presents a Gantt chart depicting the key activities, milestones, and, if applicable, decision points associated with developing this user service to a state where it is available for deployment. The accompanying supporting text identifies probable issues and describes the activities, with associated projects, identified on the Gantt chart. An issue is defined as a major potential challenge which has to be met in order to achieve deployability.

1.2.8.1 Issues:

1. What technologies and techniques are currently available for collecting, processing, and disseminating route guidance information?

2. What technologies and techniques need to be developed for collecting, processing, and disseminating route guidance information?

3. What are the safety implications of the various techniques for presenting route guidance information?

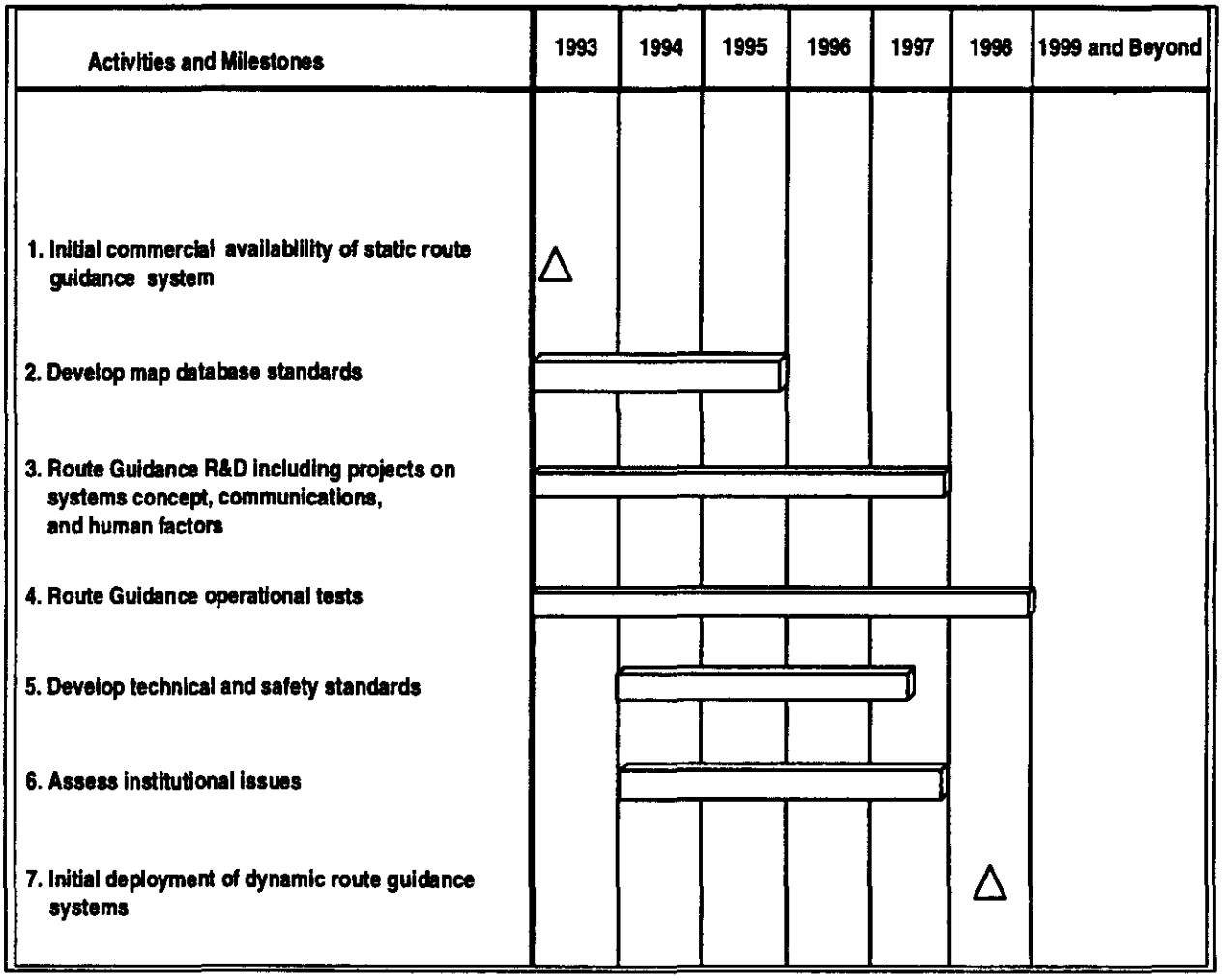

Figure 1.2-1 Route Guidance Activities

4. What are the liability issues associated with providing incorrect route guidance information?

5. How do users react to and use route guidance information?

6. What technical difficulties must be overcome to ensure that the map database is accurate and up to date?

7. What issues must be resolved concerning individual vs. system optimization and cross-jurisdictional optimization of vehicle routes?

8. How large are the actual time benefits to the user, after taking into account the time to initialize the system, download information, etc.? Is the gain in travel time significant enough to justify the use of the route guidance system by the driver?

9. How can route guidance best be integrated with other user services, such as Traffic Control (User Service No. 1.4) and Incident Management (User Service No. 1.5)?

1.2.8.2 Activities and Milestones:

1. Initial commercial availability of static route guidance systems

2. Develop map database standards

   - The Society of Automotive Engineers (SAE) Map Database Committee is developing standards so that a common referencing system for identifying traffic link I.D.s can be established.

   - The Federal Highway Administration (FHWA) is funding the Link Identification Format and Map Database Requirements project. Recommendations will be developed for standardizing the information format, content, and accuracy of a nationwide map database. A format for uniquely denoting links for any part of the country/North America will be recommended.

3. Route Guidance R&D including projects on system concept, communications, and human factors

   - FHWA is sponsoring a contract with Battelle on Human Factors in Advanced Traveler Information Systems. This project will address the impacts of driver interfaces, information type, behavioral factors, and user demographics on the development of specific information subsystems, including In-Vehicle Routing and Navigation Systems (IRANS). Human factors guidelines will be developed so that safety can be maintained.

- An FHWA study, "Analysis of Travelers' Preferences for Routing," will analyze the criteria and decision processes used by drivers for selecting routes, choosing departure time, and rerouting when encountering traffic congestion.

- An FHWA study, "ITS Communications Alternatives," will investigate various communications issues and validate particular technologies for ITS functions.

4. Route Guidance Operational Tests (Note that these tests are also evaluating other services used in conjunction with route guidance)

   - Pathfinder and TravTek are recently completed operational tests that included a route guidance component.

   - The ADVANCE project is a cooperative effort among FHWA, the Illinois Department of Transportation, Motorola, Inc., and the Illinois Universities Transportation Research Consortium (IUTRC) in the northwest suburbs of Chicago. Vehicles will serve as probes, providing travel time data to a Traffic Information Center (TIC). The TIC will fuse the probe and other real-time data and transmit the information to the equipped vehicles. The vehicles will then generate and present dynamic route guidance instructions to the drivers.

   - FAST-TRAC is a public/private cooperative effort in Oakland County, Michigan. For the route guidance portion of the test, vehicles will be equipped with the Siemens Ali-Scout system. Infrared beacons will be installed at critical locations to provide a continuous exchange of real-time traffic and route guidance information.

   - Project Northstar in New York is evaluating the effectiveness of FM subcarrier, combined with speech synthesis and cellular technology, to provide personalized incident reports and route guidance.

5. Develop technical and safety standards

   - Information Interchange, FM Subcarrier Protocol, and Human Interface standards developed under the En Route Driver Information user service are applicable here and will accommodate route guidance.

   - Based on the system architecture development effort, in fiscal year 1995, FHWA will begin development of wireless communication protocols and driver interface standards needed for advanced traveler information systems.

   - The FHWA will develop and test a multi-modal spatial data transfer standard.

6. Assess institutional issues

   - Legal issues must be addressed. These include the impact of the recommended routes on neighborhoods (e.g., routing through residential streets or in front of a hospital) and on drivers (e.g., routing through unsafe areas).

   - There are institutional issues in keeping map databases current (e.g., assigning responsibility for disseminating information about new streets) and in the implications of errors in the databases.

   - Long-term coordination will be needed to address the potential institutional problems of developing, and then maintaining, accurate, compatible map databases nationwide.

7. Initial deployment of route guidance systems

   - Initial deployment of route guidance systems will be static systems which do not rely on real-time information. Such systems are being test-marketed by the automobile industry in limited areas.

   - Deployment of dynamic route guidance systems will probably occur initially in limited areas of the country as real-time traffic information becomes available.

1.3 TRAVELER SERVICES INFORMATION

1.3.1 Introduction

The Traveler Services Information user service provides the traveler with access to information regarding a variety of travel-related services and facilities. In general, this information will be of the "yellow pages" type, organized to provide quick access to services in the local vicinity of the traveler.

The information will be accessible to the traveler in the home or office to support pre-trip planning and while en-route, either in a vehicle or at public facilities such as public transit terminals or highway rest stops to help the traveler locate critical local services. Information would be available regarding the location and status (e.g., operating hours, etc.) for a variety of services, such as food, lodging, parking, car service/repair facilities, hospitals, and police stations. This service could be particularly useful to the commercial vehicle operator traveling in unfamiliar areas. An additional feature of this service would allow the traveler to communicate with service providers interactively to make and confirm reservations, and possibly, to purchase tickets, or guarantee payments for reservations.

The type of information that will be available to the traveler and the nature of the presentation will vary depending upon whether the service is accessed by the traveler in fixed locations, while riding in a transit vehicle, or while driving a private or commercial vehicle. Safety considerations will tend to restrict the type and amount of visual information that will be provided to a driver while the vehicle is in motion. When the vehicle is parked, the driver will be free to access all available information and to conduct transactions in an interactive manner.

1.3.2 Needs

This service addresses several traveler needs, including the safety-related need to quickly locate nearby support facilities such as car service/repair stations, hospitals or police stations, etc. The ability to identify nearby facilities and to determine the traveler's location will reduce traveler anxiety, add to the feeling of security, and also reduce the possibility of the driver becoming lost while searching for them. Additionally, travelers in remote areas would be advised of the unavailability of certain services which also reduces time spent searching for them.

Another need that will be partially satisfied by this service will be the ability to inform the traveler of the status and location of facilities such as parking or other concessions in highly congested commercial/tourist areas, thereby helping to reduce congestion levels caused by drivers searching for a business establishment or for available parking nearby.

1.3.3 Service Description

The Traveler Services Information user service will provide up-to-the-minute information related to the conditions, status, and availability of traveler services, including motorist services, tourist services and other travel-related items, regardless of the traveler's mode. When fully deployed, this service will connect users, sponsors, and providers in an interactive manner to request and provide needed information. Travelers may request general information about an area or specific information about a desired service, e.g., lodging, food, parking, or special events. This would be analogous to yellow pages directory that is available on-demand. A further capability that could be supported would permit the traveler to request actions of the service provider, for example, making lodging or dining reservations. Also, more specific information may be requested, such as hours of operation, parking, tourist activities, daily events, etc.

1.3.4 Operational Concepts

Traveler Service Information would be provided to travelers in several ways. In some areas a limited amount of information would be provided as pre-recorded verbal information that is broadcast on a special radio channel or accessed through dial-up telephone lines, similar to the recorded weather information currently provided in most metropolitan areas. As personal portable advanced traveler information systems (PPATIS) become more prevalent, traveler service information could easily be provided as an additional capability on these devices.

Another mechanism for providing this information would be through the use of "yellow pages"-like directories of traveler services information that could be stored on CD-ROM and read/accessed by properly equipped computers at the home or office, or at information kiosks. Kiosks could be located in key public areas such as at rest areas along the interstates or near major cities, activity centers, or tourist attractions. They could also be located at service plazas. A motorist could access the system while in the vehicle, requesting information on service facilities or lodging, although, for safety reasons, this service may only be available when the car is stopped and the transmission is set in park.

Airline travelers looking for local points of interest and/or special events could access the system through kiosks located at the airport. This capability could be closely integrated with the services provided by the Pre-Trip Travel Information user service.

Traveler Services Information may overlap with other electronic traveler services such as banking, shopping, ticket purchase, etc. A more comprehensive, integrated service could include the ability to support financial transactions where the traveler could be billed automatically for the purchase of tickets or reservations.

1.3.5 Technologies

The following is a list of technology areas that could play key roles in the provision of this user service area:

- CD-ROM Directory databases (static databases of "yellow page" information both for vehicles and at information kiosks)
- Two-way communications for: 1) interactive request/access to databases, 2) reservation request/confirmation, 3) providing the location of the traveler for location-specific information, and 4) financial transaction support
- Query language and procedures for efficient, user-friendly access to databases
- User interface for presentation/display of services information

1.3.6 Potential Costs and Benefits

The potential costs and benefits of Traveler Services Information have been broken into public and private sector discussions.

1.3.6.1 Public Sector Costs

The major costs for the public sector would be administrative and regulatory primarily . The public sector would be responsible for establishing the regulations that would govern the development, implementation, and operation of the traveler information services in urban and rural areas. Once the services are in place, the public sector would have the responsibility for any administration and enforcement functions required. Decisions would need to be made as to whether this function would best be done by a State level agency or by local agencies, especially within a major urban area.

1.3.6.2 Private Sector Costs

The major private sector costs would be in the development, implementation, and operation of the infrastructure that is needed in order to provide the services. The infrastructure costs would include both the hardware and software systems needed to support the provision of the service. These costs are expected to be significant, especially in dense, congested urban areas.

1.3.6.3 Potential Benefits

Traveler Services Information has moderately high potential benefits. These benefits include the following:

- Reduction in the amount of wasted travel. By having easily accessible and usable traveler services information (including type of services available and instructions for locating the service provider), motorists could easily find the needed services without getting lost or making extra trips to locate specialty services.

- Savings of energy and reduced air pollution. By reducing wasted travel, energy and pollution savings would be realized.

- Reduction in accidents. By having information that is accurate and reliable, motorists would not be distracted while searching for services. Instead they would be able to concentrate on driving rather than looking for the required services.

- Increased convenience for the traveler. Accurate information would be available regarding the location of needed services (e.g., fuel and/or repair facilities).

- Improved marketing and service exposure. Having a readily accessible medium for the public and private sector providers of services (including tourist attractions and special events) can improve service marketability and exposure.

- Safety. By having quick, accurate access to service information, emergency services and facilities can be located by the traveler.

1.3.7 Assessment of Roles

Private/public sector roles for development, deployment, and operations will be variable from one region or area to another, depending upon the state and local views of the service and on the initiatives from private sector organizations. Patterns will develop that must be evaluated over time to identify those approaches that add to the safety of the traveler and efficiency of the traffic network and serve the overall needs of both the public and private sector organizations participating in the provision of this user service.

1.3.7.1 Potential for Private Investment in Development

The private sector role in the development and deployment of this user service will be high. With the exception of the development of information transfer and safety standards, which must be developed jointly by the public and private sectors, most of the actual deployment of this service will be a private sector endeavor.

The types of private sector organizations that are expected to play major roles in the development and deployment of this service are the phone companies and other providers of "yellow pages" information, local business organizations in the regional or local area covered by the service including providers of traveler/motorist/tourist services, and providers of traveler information (i.e., motor clubs and travel map providers). In addition, groups of local businesses may develop special focus information kiosks for resort/tourist areas. These kiosks may be located at rest stops along interstates/access roads in coordination with other public sector facilities.

1.3.7.2 Private and Public Sector Roles in Deployment

The role of the public sector for deployment of this service will be low. This user service will in all likelihood "piggyback" on other user services that may be provided by the public sector (i.e., Pre-Trip Travel Information, Route Guidance, and the En-Route Driver Information services). This user service will have very little direct impact on public sector efforts to deploy other ITS services. In fact, this service may provide additional incentives to the private sector to become involved in public/private ventures and to provide a means for sharing costs of deploying an ITS infrastructure to support other user services.

The following is a list of potential areas of public sector involvement and/or interest areas within this user service:

- Public Service Information
  - Event-related traffic information
  - Event-related routing and schedules
- Safety Standards
  - Displays (Graphic/Auditory)
  - Information Content/Presentation
- Common Information Channel (potentially sharing of a common traffic information channel in rural or small metropolitan areas, or use of a private communications network).
- Outreach -- Common to all initiatives
- Information Kiosks -- public sector agencies may approve the co-location of private sector kiosks in public rest facilities or may permit private sector organizations to operate a combined traffic information and traveler services information channel as a franchisee.

- Public Sector role in resolving Institutional Issues and deployment options

  - Should (and how should) public/private information be combined?
  - Merge and pay for public information carried on private channels.
  - Private information and transactions included on Public channels.
  - Authorize private sector (franchisee) to use Public channels but require inclusion of public information.

1.3.7.3 U.S. DOT Role in Developing Service

The U.S. DOT will have a very limited role in developing this service.

1.3.7.3.1 *Research and Development:* The U.S. DOT has no direct role in research and development for this service. However, R&D activities for other services, such as addressing communications, safety, human factors, or other issues, might be applicable and of interest to private sector developers of this service.

1.3.7.3.2 *Operational Tests:* The U.S. DOT role in operational testing of this service is low, except where it is provided by the private sector as an additional service in an operational test of an integrated system. The U.S. DOT would participate in these tests, since the value added by this service might make other user services more appealing to the consumer, thus increasing user acceptance and willingness to pay for ITS.

1.3.7.3.3 *Institutional and Legal:* The U.S. DOT has no direct role in addressing institutional or legal issues, except as they relate to how this service might impact, or be deployed with, other ITS user services.

1.3.7.3.4 *Deployment*: The only U.S. DOT role in deploying this service is to ensure safety.

1.3.8 Milestones and Activities

The following section describes the key activities, milestones, and, if applicable, decision points associated with developing this user service to a state where it is available for deployment. The supporting text identifies probable issues and describes activities, with associated projects, to address these issues. An issue is defined as a major potential challenge which has to be met in order to achieve deployability.

1.3.8.1 Issues

From a Federal perspective, the key issue is how this service can be provided while safety is maintained (e.g., providing the service while vehicles are in motion.)

From the perspective of a private sector provider, issues might include:

- Maintenance and updating of the business directory data.
- Advertizing aspects - Will advertisers pay extra to be first in the list? What about unsolicited advertising, e.g. while driving down the freeway, will the driver be bombarded with "specials of the day" at various exits?
- Additional services, e.g., special directories for special interest groups. Does there need to be a standard to allow others to add these specialty databases to the business data? Would this be something along the lines of the Japanese CD-CRAFT standard?

1.3.8.2 Activities

1. The only role for the U.S. DOT in this service is to ensure safety. Otherwise, the provision of this service is a private industry/free marketplace responsibility. Other Federal agencies, for example the National Park Service and the National Forest Service, could provide information which would make this service more useful in rural areas and near tourist attractions.

2. Evaluations of operational tests such as TravTek, which was aimed at rental car drivers, and ADVANCE, which is aimed at local commuters, could provide information on user response and acceptance of Travel Service Information.

3. Examine the feasibility, or operationally test the concept, of a nationally interlinked information system (e.g., a telephone or kiosk-based system) that contains traveler services information. Such a system could be accessed from any location and provide information about any other location in the country.

4. Explore transportation opportunities presented by expected telecommunication industry market initiatives. Initial activity could include technology/market assessments.

Since this service will be developed and deployed primarily by the private sector, ITS AMERICA inputs are actively solicited for the additional milestones and activities associated with this user service. The following are suggested private sector initiatives to date:

1. Investigate methods of distribution and the nature of the revenue stream for in-vehicle business directories.

2. Evaluate field operational tests that include business/travel listings (i.e. TravTek, ADVANCE, etc.)

3. Develop guidelines for the presentation of business directory information to travelers:

   - Basic information, such as location, telephone number, hours of operation, etc.

   - Expanded information, such as products sold, other services provided, charge cards accepted, etc.

   - Narrative, additional advertising material, etc.

4. Develop human factors guidelines